

**Assignment 13.2** Questions 13, 36, 38, 40, 44, 46, 48, 54

13) K (or K<sub>c</sub>) are the equilibrium constants based on concentrations.

K<sub>p</sub> is the equilibrium concentration based on partial pressures of gases.

Q is the reaction state, but not necessarily at equilibrium.

$$36) a. Q = \frac{[0.22][0.10]}{[0.010][0.010]} = 220 \quad Q > K \text{ (will shift left)}$$

Equilibrium of water will decrease as equilibrium is established

$$b. Q = \frac{[0.22][0.0020]}{[0.0020][0.10]} = 2.2 \quad \text{Already at equilibrium (stays the same)}$$

$$c. Q = \frac{[0.88][0.12]}{[0.044][6.0]} = 0.4 < K \quad [H_2O] \text{ will increase (shifts right)}$$

$$d. Q = \frac{[4.4][4.4]}{[0.88][10.0]} = 2.2 \quad \text{Already at equilibrium (stays the same)}$$

$$e. 2.2 = \frac{[2.0][H_2O]}{[0.10][5.0]} \quad [H_2O] = 0.55M$$

f. [H<sub>2</sub>O] is included because water is a solute in this reaction.

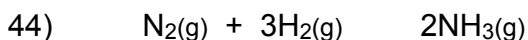
$$38) K_p = \frac{P_{NOBr}^2}{P_{NO}^2 P_{Br_2}} = 109 = \frac{(0.0768)^2}{P_{NO}^2 (0.0159)} \quad P_{NO} = 0.0583 \text{ atm}$$

40)

	P <sub>S<sub>8</sub></sub> (atm)	P <sub>S<sub>2</sub></sub> (atm)
Initial	1.00	0
Change	- 0.75	+ 4(0.75)
Ending	0.25	3.00

4 S<sub>2</sub> produced for each S<sub>8</sub>

$$K_p = \frac{P_{S_2}^4}{P_{S_8}} = \frac{(3.00)^4}{(0.25)} = 320$$



	P <sub>N<sub>2</sub></sub> (atm)	P <sub>H<sub>2</sub></sub> (atm)	P <sub>NH<sub>3</sub></sub> (atm)
Initial	1.00	2.00	0
Change	- x	- 3x	+ 2x
Ending	1 - x	2 - 3x	2x

$$(1 - x) + (2 - 3x) + 2x = 2 \quad (\text{sum of final partial pressures is 2.00 atm})$$

$$3 - 2x = 2$$

$$x = 0.5$$

$$P_{H_2} = 2 - 3(0.5) = 0.50 \text{ atm}$$

46)  $K = \frac{[HI]^2}{[H_2][I_2]} = 1.00 \times 10^2$

	$[H_2] (M)$	$[I_2] (M)$	$[HI] (M)$
I	1.00	1.00	1.00
C	- x	- x	+ 2x
E	1 - x	1 - x	1 + 2x

$$\frac{[1+2x]^2}{[1-x][1-x]} = \frac{[1+2x]^2}{[1-x]^2} = 1.00 \times 10^2$$

$$\frac{[1+2x]}{[1-x]} = 10.0 \quad \text{Took square root of both sides}$$

$$[1+2x] = 10 [1-x]$$

$$1 + 2x = 10 - 10x$$

$$12x = 9$$

$$x = 0.75 M$$

$$[H_2] = [I_2] = 1 - 0.75 = 0.25M$$

$$[HI] = 1 + 2(0.75) = 2.50M$$

54)

	$P_{COCl_2} (atm)$	$P_{CO} (atm)$	$P_{Cl_2} (atm)$
I	1.00	0	0
C	- x	+ x	+ x
E	~1.00	x	x

$$\frac{P_{CO} \times P_{Cl_2}}{P_{COCl_2}} = \frac{x^2}{(\sim 1.00)} = 6.8 \times 10^{-9}$$

$$x^2 = 6.8 \times 10^{-9}$$

$$x = 8.2 \times 10^{-5} atm$$

Because  $K_p$  is so small, we will assume  $x$  is extremely small

$$[CO] = [Cl_2] = 8.2 \times 10^{-5}M$$

$$[COCl_2] = 1.00 - 8.2 \times 10^{-5} = 1.00M$$

48)  $K = \frac{[HOCl]^2}{[H_2O][Cl_2O]} = 0.090$

$$\frac{1.0g H_2O}{18.016g H_2O} \times \frac{1 mol H_2O}{18.016g H_2O} = 0.0555 mol H_2O$$

$$\frac{(2x)^2}{(0.0555-x)(0.0230-x)} = 0.090$$

$$\frac{2.0g Cl_2O}{86.90g Cl_2O} \times \frac{1 mol Cl_2O}{86.90g Cl_2O} = 0.0230 mol Cl_2O$$

$$4x^2 = (0.0555-x)(0.0230-x) 0.090$$

remember FOIL?

$$4x^2 = (0.00128 - 0.0785x + x^2)0.090$$

$$4x^2 = 1.15 \times 10^{-4} - 0.00707x + 0.090x^2$$

$$0 = 1.15 \times 10^{-4} - 0.00707x - 3.91x^2$$

	$[H_2O] (M)$	$[Cl_2O] (M)$	$[HOCl] (M)$
I	0.0555	0.0230	0
C	- x	- x	+ 2x
E	0.0555 - x	0.0230 - x	2x

$$x = 4.6 \times 10^{-3} \text{ or } (-6.4 \times 10^{-3})$$

$$[HOCl] = 2x = 0.0092 M$$

$$[H_2O] = 0.0555 - 0.0046 = 0.051M$$

$$[Cl_2O] = 0.0230 - 0.0046 = 0.018M$$

b.

	$[H_2O] (M)$	$[Cl_2O] (M)$	$[HOCl] (M)$
I	0	0	0.50
C	+ x	+ x	-2x
E	x	x	0.50-2x

$$\frac{(0.50-2x)^2}{x^2} = 0.090$$

$$(0.50-2x)^2 = 0.090 x^2$$

$$0.50-2x = 0.30 x$$

$$0.50 = 2.30x \quad x = 0.217M$$

$$[H_2O] = [Cl_2O] = 0.22M$$

$$[HOCl] = 0.50 - 2(0.217) = 0.07 M$$